

few miles only of the photospheric clouds. (It does not seem necessary to suppose it to take place within or between the clouds, although this may, of course, be the case to some extent.)

The flash spectrum, however, as we see it, represents the higher part of the stratum, which is not nearly so effective in producing absorption, on account of the much lower density; and if the various gases concerned are not uniformly distributed throughout the layer, the relatively shallow but dense stratum at the base may contain gases which are not present in the region above, and *vice versa*.

On this view, helium and other gases having prominent lines in the flash spectrum, which are only feebly represented, or are not present at all, in the Fraunhofer spectrum, are gases which exist only in the upper regions of low density. It is not necessary to suppose that the temperature of these gases is as high as that of the photospheric background, but simply that a ray of light, emitted by the photosphere in its passage outwards, encounters relatively few molecules, notwithstanding that the gases may extend to great elevations in the chromosphere.

It is evident that the strength of a bright line in the chromosphere or flash spectrum depends to a large extent on the height to which the gas producing it extends, and is independent of the density or total quantity of gas overlying the photosphere by which the intensities of the dark lines are mostly determined.

Thus, by assuming a somewhat irregular distribution of the gases in the layer itself, the differences between the Fraunhofer and flash spectra may be accounted for without abandoning the view that the greater part, if not the whole, of the gaseous absorption takes place between the photosphere and the upper limits of the reversing layer.

Note on the Zodiacal Light. By E. Walter Maunder.

The recent eclipse expedition to India gave me the first favourable opportunity for observing the Zodiacal Light. I had seen it on a few occasions in England, but the contrast between the faint glimmer, doubtfully seen on a few rare occasions here, and the broad bright glow, which it was impossible to mistake or overlook, seen on every moonless evening during both the outward and homeward voyage, and during our camp life in India, was so great as to seem to make it a duty to utilise such an opportunity as fully as possible. The observations cover a period of two calendar months—1897 December 22 to 1898 February 22—they are, of course, therefore of but little value as compared with a series of observations carried on continuously throughout the entire course of the year. Nevertheless I thought it worth while to submit them to the Society in the hope that they might call the attention

of observers in tropical stations to an object which has been as yet but little studied, and which demands no instrumental equipment.

The first point which struck me with regard to the Light was its brilliance, so far exceeding anything that I had anticipated. I estimated that the brightest regions of the Light, as seen in the evening, were fully six times as bright as the brightest regions of the Milky Way visible at the same time. The morning branch of the Light seemed to me hardly equal to the evening branch, and it was brought into rivalry with brighter regions of the Milky Way—namely, those in *Sagittarius*, *Crux* and *Argo*. I should incline to place it as about three times as bright as the brightest of these. Again, in the evening the Light made itself evident in the twilight considerably before the Milky Way was able to do so, and as seen at sea its reflexion on the water was much more marked.

The question at once occurred to me, is the Light always as bright as this in these latitudes, or are we being favoured with a specially brilliant display? If the former were the case, it seemed impossible to understand why so few people seem to have remarked it, and why the observations of it by astronomers are so rare and incomplete. I made what inquiry I could on this point and found a conflict of testimony; some observers assuring me that in India, at all events under latitude 20° , the Light was habitually as bright as I had seen it; others were just as positive that it had been unusually distinct at this particular season. My own experience, such as it is, would seem rather to support the latter view. Most assuredly the Light was in no such evidence in 1886 during our eclipse voyage to the West Indies, or I could not have failed to have noticed it. I may note that Father Marc Dechevrens of the Zi-ka-Wai Observatory, failed to observe the evening branch during the months of July to September, in the years 1875 to 1879.

It will, of course, be understood that the entire Light was not of this intensity. The brightest portion of the Light was spindle-shaped—the axis of the spindle being the brightest part, and the light shading off in all directions. But whilst the sides of the spindle were not so diffused as to render it impossible to trace their outlines with a fair amount of exactness, the Light at the point faded away so gradually that it was impossible to set a definite boundary to it there. Roughly speaking, the Light was distinctly brighter than the Milky Way for fully 30° of its length. At perhaps 45° it might be of about the same intensity. After this it degraded very rapidly, and when it crossed the Milky Way between *Taurus* and *Gemini* it was quite overpowered by the latter.

A more precise idea of the brilliance of the Light may be deduced from the fact that the young Moon was seen upon it on January 24 and February 22 without the Light suffering extinction. On both occasions it could be clearly made out. On the following

nights, January 25 and February 23, the increased moonlight was sufficient to overcome it.

Beyond the brighter spindle-shaped light a very faint band of light could be traced in a prolongation of the spindle nearly, if not quite, round the entire sky ;—at least it could be so traced at the end of December, for I had no opportunity of observing the morning branch of the Light after January 2. During the three weeks in camp the morning Moon interfered almost continuously with the observations of the eastern Zodiacal Light, and on the homeward voyage, though I rose nearly every morning between four and five o'clock, on no single occasion was the sky clear.

The failure to see the morning branch was the more disappointing as the evening branch appeared to shorten as time went on. On the very first occasion, *i.e.* on the evenings of December 22, 23, and 24, the evening branch was traced as far as ι Tauri. On February 21 it was scarcely seen so far—certainly no further, the elongation from the Sun being 164° in the first case, and only 102° in the second. It is possible that the brightness of the Milky Way, which crosses the ecliptic near here, was sufficient to drown the feeble glow of the Zodiacal Light at so great an elongation, and that but for its interruption it might have been traced as far from the Sun in February as in December. It was both broader and brighter in the neighbourhood of the Pleiades on the later occasion than on the earlier. As the observations given below indicate, the “spindle” was shorter and broader, was less oval, when last seen than when seen first.

The morning Light could not be traced quite so close to the Milky Way as the evening branch. *Præsepe* marked the furthest point to which it was followed to any degree of certainty. This on January 2 would correspond to an elongation of 156° .

The brightest portion of the Light showed a delicate but unmistakable colour—a faint pale yellow, with perhaps the slightest inclination to the green rather than to the orange. The contrast between this tint and the steely blue of the Milky Way was only less pronounced than the contrast between the broad areas of diffused luminosity of the Zodiacal Light and granulations of the Galaxy. Yet they had one feature in common. I felt convinced that in the Light as in the Galaxy there were dark lanes and rifts, though in the former these lanes are far more difficult objects, and I was not able to lay down the course of any of them with sufficient accuracy. Two lines of somewhat rapid fading, if not positive dark lanes, were suspected at right angles to the ecliptic near longitudes 16° and 25° respectively.

A feature of the Light which especially caught my attention was that it very nearly swamped the stars of the two streams in *Pisces* which radiate from α *Piscium*. The one stream running in a straight line from α to ρ *Piscium* is very nearly normal to the ecliptic ; the other, forming a gentle curve and running from α to γ *Piscium*, crosses the Light at a small angle.

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The individual stars in these two streams, though many of them are fully of the fourth magnitude, were yet made out with considerable difficulty, especially those near the axis of the Light. I have had no opportunity of examining this part of the sky again since my return home, but so far as my recollection serves me these and other ecliptic stars in *Aquarius* and *Capricornus* were seen with more difficulty in the clear skies of the Red Sea and India than here at home, owing entirely to the great brilliance of the Light.

Beside the morning and evening branches of the Light, a very faint, vague luminosity was observed night after night from January 12 to January 18, lying between *Pollux*, *Procyon*, and *Præsepe*. It had at first seemed to be like a faint extension of the Milky Way, but on January 18 for the first time a clear interval was made out between the following side of the Milky Way and the preceding edge of this faint light. The Light itself was traced about 2° farther east than *Præsepe*. The centre, therefore, of the light was about longitude 112° . It was, therefore, as nearly as the observations allowed, in opposition to the Sun, and was no doubt what is now known as the "Gegenschein."

Below I give a series of outline points as determined on different occasions. It will be noticed that, so far as they go, they point to the Light being very nearly in the plane of the ecliptic; rather in that plane than in the plane of the Sun's equator. How far a more expanded series of observations would have confirmed this view, of course, I cannot say. The fact that the Light can be traced more than 90° from the Sun (indeed, if the Gegenschein be part of it, to actual opposition with the Sun), clearly proves that some portion of the Light is derived from matter lying outside the Earth's orbit. But by far the greater amount of the Light is concentrated in the spindle-shaped beam, and this although, as already stated, the place of its apex cannot be satisfactorily fixed, does not attain anything like so great an elongation, and it seems to me clear, if the Light were due to a disc of matter extending uninterruptedly outwards from the Sun to a considerable distance beyond the Earth's orbit, that the opposition portion would tend to appear much broader than is actually the case. The evening branch of the Light tapers from a breadth of 15° or 16° near the Sun, to one of 4° or 5° near opposition; and the morning branch is about 20° broad at its nearest observable approach to the Sun, and 4° at its greatest distance from it. But the particles between the Earth and the Sun must be "new," that is, invisible, whilst those either in opposition to the Sun, or on the further side of it, are "full." The fully illuminated particles are therefore much nearer to us in opposition, and consequently spread over a greater area, than those nearer superior conjunction, and if the Light were due simply to a continuous disc of particles extending outward from the Sun beyond the Earth's orbit, the portion of it opposite the Sun should be the broadest, not the narrowest.

On the other hand, if we suppose that such a disc of particles lies wholly within the Earth's orbit, its boundary extending say to 0.94 (corresponding to an elongation of 70°) of the Earth's mean distance from the Sun, we should have a glow of much the appearance and character of the brightest part of the Light, the "spindle-shaped" beam, the "Stronger Light" of Jones. The faint, narrow prolongation of the Light seen beyond an elongation of 70° , and traced even to opposition, showing as it does little variation in breadth, would seem to point to a flat ring of matter lying a good way outside the Earth's orbit. A satellite of *Saturn* revolving round its primary in the middle of the Cassinian division of the rings, would offer some analogy to the position of the Earth with regard to the two divisions of the Zodiacal Light.

When the region of the *Pleiades* is approached it seems very difficult to differentiate between the actual Light and faint, indistinct patches and arms of luminosity, which seem to be connected with and to radiate from the *Galaxy*.

But by far the brightest portion of the Light is satisfactorily accounted for by the usual hypothesis of a great disc of finely divided cosmical particles radiating from the Sun.

The plane of the disc seems to me very nearly to coincide with the plane of the ecliptic. The annexed observations made in February show that the Light then lay almost exactly along the ecliptic. The heliographic latitude of the Earth was then $7^\circ.2$ S. If, therefore, the disc extends to within a few million miles of our orbit, and if it lie in the plane of the Sun's equator, it should have shown an enormous displacement to the north of the ecliptic, which was most certainly not the case. In fact, the Light appeared if anything to lie further south in February, when the Earth was at its maximum south heliographic latitude, than in December when its latitude was only 3° .

I should like to add that I had read very little on the subject before leaving England, and had therefore not seen Professor Arthur Searle's suggestion for observing the Zodiacal Light by the method of contour lines. I greatly regret this, as the method, though requiring much practice, was obviously the proper one to have adopted.

EVENING ZODIACAL LIGHT.

(1) Observations made 1897 December 22, 23, and 24.

Northern Border.	Southern Border.
2° N. α Capricorni	ψ Capricorni
ϵ Aquarii	ζ "
μ "	35 Aquarii
β "	3° N. δ "
1° S. γ Aquarii	1° S. ψ^3 "
1° S. η "	1° N. 30 Piscium

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Northern Border.

1° S. γ Piscium
 " "
 ω "
 η "
 2° S. γ Arietis
 Between ζ and δ Arietis
 1° S. Pleiades

Southern Border.

1° S. μ Piscium
 Midway between π
 and α Piscium }
 ξ Arietis
 Between 31 and 38 Arietis
 1° N. ϵ Tauri
 " "

(2) *Observations made 1898 January 15.*

β Aquarii	Just N. δ Aquarii
1° S. γ "	Just S. ψ^3 "
1° S. η "	30 Piscium
1° S. γ Piscium	1° N. 20 Ceti
ω "	ν Piscium
η "	Just N. ϵ Tauri
ζ Arietis	
Just S. Pleiades.	

(3) *Observations made 1898 February 16, 19, 20 and 21.*

2° N. γ Piscium	ι Ceti
1° N. ι "	6° N. η "
3° N. ω "	6° N. θ "
4° S. γ Pegasi	1° N. α Piscium
1° N. η Piscium	3° N. ξ Tauri
1° S. γ Arietis	Just N. ϵ "
Just N. Pleiades.	

MORNING ZODIACAL LIGHT.

Observations made 1897 December 27 and 1898 January 2.

1° N. ξ Scorpii	ρ Scorpii
3° N. β Libræ	39 Libræ
3° N. δ "	1° N 20 Libræ
1° N. μ Virginis	4° S. λ Virginis
1° N. ζ "	$\frac{1}{2}$ ° S. α "
δ "	3° S. γ "
1° S. σ "	2° S. η "
5° S. β Leonis	1° S. β "
$1\frac{1}{2}$ ° S. θ "	Between σ and τ Leonis
1° N. η "	ρ Leonis
γ Cancri	α "
	δ Cancri.

The approximate latitudes at the times of observation were :—

1897 Dec. 22	31° 0' N. Lat.	1898 Jan. 15	20° 45' N. Lat.
23	31 0	Feb. 16	13 30
24	26 0	19	21 30
28	13 30	20	27 0
1898 Jan. 2	18 0	21	29 0

Mean areas and heliographic latitudes of Sun-spots in the year 1896, deduced from photographs taken at the Royal Observatory, Greenwich, at Dehra Dûn (India), and in Mauritius.

(Communicated by the Astronomer Royal.)

The results here given are in continuation of those printed in the *Monthly Notices*, vol. lviii. p. 40, and are deduced from the measurements of solar photographs taken at the Royal Observatory, Greenwich, at Dehra Dûn, India, and at the Royal Alfred Observatory, Mauritius.

Table I. gives the mean daily areas of umbræ, whole spots, and faculæ for each synodic rotation of the Sun in 1896; and Table II. gives the same particulars for the entire year 1896 and the seven preceding years for the sake of comparison. The areas are given in two forms. First, projected areas—that is to say, as seen and measured on the photographs, these being expressed in millionths of the Sun's apparent disc; and next, areas as corrected for foreshortening, the areas in this case being expressed in millionths of the Sun's visible hemisphere.

Table III. exhibits for each rotation in 1896 the mean daily area of whole spots, and the mean heliographic latitude of the spotted area for spots north and for spots south of the equator, together with the mean heliographic latitude of the entire spotted area, and the mean distance from the equator of all spots; and Table IV. gives the same information for the year as a whole, similar results from 1889 to 1895 being added, as in the case of Table II. Tables II. and IV. are thus in continuation of the similar tables for the years 1874 to 1888 on pp. 381 and 382 of vol. xlix. of the *Monthly Notices*.

The rotations in Table I. and Table III. are numbered in continuation of Carrington's series (*Observations of Solar Spots made at Redhill*, by R. C. Carrington, F.R.S.), No. 1 being the rotation commencing 1853 November 9. The assumed prime meridian is that which passed through the ascending node at mean noon on 1854 January 1, and the assumed period of the